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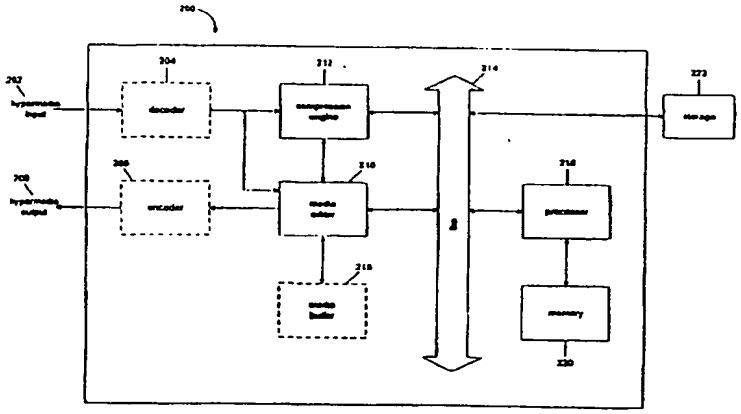

NON-LINEAR EDITOR

(57) Abstract

A non-linear editing system for home audio and video applications includes a compression/decompression engine, a high capacity storage device and a media editor that provides point and click audio and video editing functionality, including recording, playback and special effects, such as real time gamma correction, color effects, 2D effects and real time fades, using a time-line system. The compression/decompression engine includes electronic circuitry designed to implement high speed data compression and decompression using JPEG, MPEG, or wavelet techniques. The high capacity storage device typically comprises internal and external non-linear magnetic storage devices, such as Enhanced IDE or SCSI hard drives, although other non-linear storage devices, such as magneto-optical or optical disk drives may be used. Similarly, the system includes input/output (I/O) capability for video in composite NTSC or PAL formats including *SVHS resolutions*, analog and digital stereo audio in 16-bit CD format, multimedia inputs, such as clip art and synchronized audio/video, from CD-ROMs and DVDs, a Musical Instrument Digital Interface (MIDI) and Internet connectivity through strandard telephone lines using a modem and through cable TV lines. The system does not require the use of a computing device, such as a personal computer, to perform its non-linear editing functions.

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Non-Linear Editing System for Home Entertainment Environments

Background of the Invention

Field of the Invention

The invention relates to non-linear editing systems and, more particularly, to consumer systems for the storage, editing and retrieval of audio/visual information.

Description of the Related Technology

Linear video editing systems, such as those for videotape and photographic film, are old in the art. In contrast, current personal computer (PC) systems, such as those of the Apple® Macintosh® and Intel® architecture, offer non-linear video editing systems. Non-linear editing on computer oriented systems involves digitizing analog media data recorded from a linear source, such as videotape or film, and storing the digitized media data on a storage device, such as a magnetic disk drive. Once digitized, the non-linear editing system permits rapid access to media data at any point in the linear sequence for subsequent manipulation of media data portions into any order. For example, non-linear editing systems enable the combination of audio clips with other video clips and the formation of new clips using portions of other clips.

The non-linear video editing capability typically resides in a plug-in card for the NuBus or PCI expansion bus of a Macintosh architecture PC or the ISA, EISA or PCI expansion bus of an Intel architecture PC. These non-linear video editing systems typically use compression techniques developed by the Joint Photographic Experts Group (JPEG) or the Motion Picture Experts Group (MPEG). For example, in U.S. Patent No. 5,577,190, Peters discloses a media editing system that receives, digitizes, stores and edits audio and video source material, using JPEG compression, for later manipulation by a computer, such as an Apple Macintosh. Similarly, in U.S. Patent No. 5,508,940, Rossmere, et al., disclose a multimedia random access audio/video editing system including a main control unit that receives data and commands over a SCSI bus from a personal computer having an analog I/O board coupled to audio and video processing boards using JPEG compression. Moreover, Reber et al. disclose a system and method for the management of media data in a non-linear editing system that enables dynamic linking of digitized media data with a specific source reference at run time in U.S. Patent No. 5,584,006. Lastly, in U.S. Patent No. 5,438,423, Lynch, et al., disclose a system and method for continuously storing the video content of a program, using JPEG or MPEG compression, in a recirculating random access buffer having sufficient capacity to store a substantial portion of the program.

Unfortunately, consumers currently have no cost effective alternatives for enhancement of their camcorder movies and digital pictures without having to incur substantial costs to purchase a personal computer with a high resolution computer graphics monitor, associated add-in cards and software for non-linear editing. In addition, conventional non-linear editing systems are designed for expert users, such as a professional movie editor, to edit a large number of unrelated movie clips stored on the same linear film or videotape. Thus, conventional non-linear editing system tools are complex and require a high degree of manual interaction and configuration to produce a final edited result. In contrast, consumers often capture closely related events, such as vacations and birthday parties,

on videotape using their camcorders. To edit these camcorder tapes, consumers require easy to use non-linear editing systems that facilitate editing without a high degree of computer or editing skill and time spent to configure plug-in cards and software. Similarly, manufacturers currently have no viable, cost effective means for incorporating non-linear editing functionality into their home entertainment components because currently available non-linear editing systems are specifically adapted for personal computer plug-in applications and functionality, instead of home entertainment components. Conventional non-linear editing systems, such as Adobe® Premiere®, provide user interfaces designed for rendering on high resolution non-interlaced computer graphics monitors. Although computer graphics monitors are viewed from a distance of one to two feet, consumers must often zoom-in on portions of the user interface to perform non-linear editing functions. In contrast, conventional television sets having low resolution interlaced displays, commonly available in home entertainment environments, render poor quality images of these user interfaces designed for high resolution graphics monitors. To compound matters, consumers often view their television sets from a distance of several feet, where a poor quality rendition of a user interface severely impedes its use. Consumers require a non-linear editing system adapted for use with conventional television sets.

Lastly, current personal computer based non-linear editing systems are specifically adapted to an RGB (red, green and blue) color space used for non-interlaced computer graphics monitors or CRTs. However, RGB is a poor choice for representing real-world images because equal bandwidths are needed to describe each color component while the human eye is more sensitive to luminance (the Y or black and white component) than color components (the U and V components). Similarly, equal bandwidth provides the same pixel depth and display resolution for each color component, which dramatically increases the cost of non-linear editing systems due to the need for expensive dual port video RAMs, instead of low cost synchronous DRAMs, to support the high bandwidth requirements. Moreover, conventional non-linear editing systems increase system cost by using additional dedicated processors, such as audio DSPs or the CPU of the personal computer, for audio editing functions. In summary, consumers have a substantial unmet need for cost effective, non-linear editing systems for home audio and video applications that do not require the use or purchase of an expensive personal computer.

Summary of the Invention

The present invention provides an economical solution for the incorporation and editing of hypermedia, such as motion pictures, music, animation and photographs, into a wide variety of present and future platforms. By eliminating the need for a costly personal computer, the present invention enables the incorporation of conventional home entertainment components, such as VCRs, camcorders and compact disc players, into an economical, stand-alone, non-linear hypermedia editing system. The present invention allows consumers to capture hypermedia from real-time on-line sources, such as broadcast radio and television, pay per view cable/satellite television services and the World Wide Web portion of the Internet, as well as off-line sources, such as video cassette tapes, laserdiscs, DVDs and compact discs. Analog hypermedia is digitized and may be compressed for storage. Consumers may replay the captured hypermedia in addition to selectively capturing and manipulating hypermedia portions, or clips, using the graphical user interface (GUI) of the present invention. Captured clips appear as icons on the GUI and consumers may combine captured clips by manipulating their respective icons to effect a wide variety of editing functions, such

as fades, dissolves, wipes, and animated effects. Moreover, consumers may also use the point, click, drag and drop functionality of the GUI to integrate captured clips onto a timeline to form a motion picture clip. In a similar manner, consumers may edit and incorporate still photographs, audio, text and other data for incorporation into a clip. Lastly, the present invention provides for a wide variety of output mediums for the edited results, such as television sets, color printers, videotapes, DVDs, computer displays and audio speakers.

One aspect of the present invention includes a non-linear editing system comprising a remote control to provide command signals, a main unit, responsive to the command signals, having a non-linear editor to receive, access, and edit hypermedia and a direct access storage device to capture the hypermedia, and an output device in communication with the main unit to receive and play the hypermedia.

Another aspect of the present invention includes a non-linear editor comprising a bus; a processor, in communication with the bus, to control access to the bus; a memory in communication with the processor; a compression engine, in communication with the bus, to compress and decompress hypermedia; a storage, in communication with the bus, to capture and provide direct access to the compressed hypermedia; and a media editor, in communication with the compression engine and the bus, the media editor and the compression engine receiving the hypermedia, wherein the media editor manipulates the hypermedia.

Yet another aspect of the present invention includes a method of operating a non-linear editing system comprising the steps of capturing hypermedia, automatically loading the previously captured hypermedia and providing a storyboard to manipulate the previously captured hypermedia.

Lastly, yet another aspect of the present invention includes a method of editing hypermedia in a non-linear editing system comprising the steps of capturing a plurality of hypermedia portions to a storyboard and automatically providing a transition between a pair of hypermedia portions within the plurality of hypermedia portions on the storyboard.

Brief Description of the Drawings

Figure 1 is a block diagram illustrating an example of an environment for practicing the present invention.

Figure 2a is a front side elevational view of an embodiment of a remote control of the present invention.

Figure 2b is a top plan view of the remote control shown in Figure 2a.

Figure 3 is a block diagram illustrating the major functional units of the remote control shown in Figure 2.

Figure 4a is a front side elevational view of an embodiment of a main unit of the present invention.

Figure 4b is a cutaway front side elevational view of an embodiment of an open connector panel of the main unit of Figure 4a.

Figure 4c is a rear side elevational view of the main unit shown in Figure 4a.

Figure 5 is a block diagram illustrating the major functional units of a main unit of the present invention.

Figure 6 is a block diagram illustrating the architecture of a media editor of the present invention.

Figure 7 is a flowchart illustrating a method of operating the non-linear editing system of the present invention.

Figure 8 is a flowchart illustrating a method of manipulating hypermedia of the present invention.

Figure 9 illustrates an embodiment of a graphical user interface for the capture of hypermedia.

Figure 10 illustrates an embodiment of a graphical user interface having a storyboard.

Figure 11 illustrates an embodiment of a graphical user interface for the creation of a transition.

Figure 12 illustrates an embodiment of a graphical user interface for the creation of graphics.

Figure 13 is a task flow diagram illustrating the tasks a consumer can perform using the graphical user interface of the present invention.

Figure 14 is a diagram illustrating the display flow of the graphical user interface of Figure 9.

Detailed Description of the Preferred Embodiments

The following detailed description of the presently preferred embodiments presents a description of certain specific embodiments to assist in understanding the claims. However, one may practice the present invention in a multitude of different embodiments as defined and covered by the claims.

For convenience, the description comprises four sections: the Non-Linear Editing System, the Media Editor, Operation of the Non-Linear Editing System and Summary. The first section describes the non-linear editing system of the present invention, the next section provides an overview of the media editor of the present invention, the following section describes the operation of the non-linear editing system and the remaining section summarizes advantageous features of the present invention.

The term hypermedia refers to the integration of text, graphics, sound, video, and other data, or any combination into a primarily associative system for information presentation, storage and retrieval. For example, hypermedia includes motion pictures, music, animation and photographs. Hypermedia environments enable users to make associations between topics. For example, a hypermedia presentation on navigation may include associations, or links, to such topics as astronomy, bird migration, geography, satellites and radar. Multimedia, the combination of sound, graphics, animation and video information, is related to hypermedia in that hypermedia combines the elements of multimedia with associations to link the information.

I. Non-Linear Editing System

Figure 1 illustrates an environment for practicing the present invention. A non-linear editing system 100 of the present invention communicates with a network 102. Network devices may include computing devices, cable and satellite TV tuners, Web television sets, wireless phones and information kiosks, among others. Computing devices communicating with the network 102 may include clients, such as a network computer and a mobile computer 110, and servers 112, such as a wide area network 114 including a plurality of local area networks 116, each having associated computing devices. To obtain hypermedia, such as television programming and Internet data, network devices communicate with the network 102 using a network connection 104. Network connections 104 may include wired links, such as those connected to the public switched telephone network (PSTN) and a cable television provider, and wireless links 106, such as cellular phones, mobile computer cellular digital packet data (CDPD) modems and satellite dishes 108.

The non-linear editing system 100 includes an output device 120, such as a home television set, a main unit 122, in communication with the output device 120, providing the non-linear editing functions and a remote

control 124. The non-linear editing system may also include hypermedia recording devices 126, such as a video cassette recorder (VCR), video camera, camcorder or digital video disk (DVD) recorder. The remote control 124 communicates all editing and playback functions to the main unit 122 for display on the output device 120 preferably using wireless techniques, such as infrared or radio waves. However, the remote control 124 may also communicate with the main unit 122 using a wired connection.

Figure 2a illustrates a front side view of one presently preferred embodiment of the remote control 124. Referring now to the top view of Figure 2b, the remote control 124 includes a keyboard 130 having a plurality of keys or buttons to communicate editing functions to the main unit 122 (Figure 1). The keyboard 130 provides for generation of alphanumeric characters, such as those used in home video titles, flying text, logos or graphics. The remote control 124 may also provide special keys 132, such as cut, paste and help buttons, and a pointing device 134, such as a mouse, touch pad, track ball or light pen. The pointing device 134 provides for control of the on-screen cursor on the viewing device 120 (Figure 1) to select, scroll or move along a selected path. Moreover, the remote control 124 may also include a jog/shuttle wheel 136 enabling rapid selection of an individual frame of a motion picture. In a preferred embodiment, the remote control 124 includes a configurable device capable of operating as a pointing device 134 and a jog/shuttle wheel 136. Using software, a user may configure the pressure sensitive buttons 134, 136 of the configurable devices to operate either as a pointing device or as a jog/shuttle wheel. When operating as a pointing device, the on-screen cursor acceleration is proportional to the pressure of user exertion on the button 134, 136. Advantageously, a configurable device enables proficient operation of the pointing device and the jog/shuttle wheel by both left handed and right handed users. Lastly, the remote control 124 may accept power from a portable power source, such as rechargeable and non-rechargeable batteries, as well as AC power from a wall socket.

Referring now to Figure 3, a block diagram illustrates the major functional units of the remote control 124. The remote control 124 includes a keyboard processor 142, such as the UR5HCSPI keyboard controller available from USAR Systems, which receives power from a power system 146, such as a battery or AC power source, and processes electrical signals representing user commands from a keyboard 144. The keyboard processor 142 may also accept electrical signals representing user commands from a pointing device 148 and a jog/shuttle wheel 150. Lastly, the keyboard processor 142 may provide its output signal to a wireless transmitter 152, which provides a wireless signal for communication with the main unit 122 (Figure 1).

Figure 4a illustrates a front view of one presently preferred embodiment of the main unit 122 of the present invention. Figure 4b provides a cutaway view of an embodiment of an open connector panel 160 of the main unit of Figure 4a. The connector panel 160 includes a video signal input 162, such as an RCA receptacle and a S-video receptacle, an audio signal input 164, such as left and right channel RCA receptacles, a microphone input 166 and a headphone input 168 having a volume adjustment. Lastly, Figure 4c illustrates a rear view of an embodiment of the main unit 122. In a preferred embodiment, the main unit 122 includes a SCSI port 172, an RS232 serial port 174 and a parallel port 176. The main unit 122 may also include a Universal Serial Bus (USB) connector, a PC Card connector and an IrDA compliant infrared port for communication with with various network devices. Moreover, the

main unit 122 preferably includes input and output connectors for coaxial cable 178, a composite video input and output connector 180 for video signals from a VCR or video recorder, S-video input and output connectors 182, left/right channel audio output connectors 184 for a television set, left/right channel audio output connectors 186 for a VCR, and left/right channel audio input connectors 188 for an auxiliary audio component, such as a compact disc player.

Referring now to Figure 5, a block diagram illustrates the architecture of the non-linear editor 200. The non-linear editor 200 receives hypermedia input 202 from a variety of on-line and off-line sources in a wide variety of formats. For example, the non-linear editor may receive separate analog YUV video signals and stereo audio signals from a VCR or multiplexed MPEG data packets from a digital satellite broadcaster. Thus, the non-linear editor 200 may include an optional decoder 204 having an analog to digital converter to convert the hypermedia input 202 into compatible digital data formats, such as CCIR 601 and CCIR 656 compliant bit streams or serial digital audio bit streams, for editing and storage. For example, the decoder 204 may convert encoded scrambled analog signal into decoded descrambled compatible digital data formats having separate audio and video components for subsequent use. Similarly, the non-linear editor 200 may include an optional encoder 206 having a digital to analog converter to convert compatible digital data format into a hypermedia output 208. For example, the encoder 206 may convert a compatible digital data format, such as a 24 bit RGB color bitmap file, into a hypermedia output 208 including an analog YUV signal for an interlaced television display with a separate synchronized analog stereo signal for home speakers or headphones.

The non-linear editor 200 includes a media editor 210 in communication with a compression engine 212, which compresses and decompresses data, a bus 214, and an optional media buffer 216 for temporary storage. The non-linear editor 200 likewise includes a processor 218 in communication with the bus 214, a memory 220 and a storage 222. The media editor 210 and the compression engine 212 simultaneously receive the hypermedia input 202. In this manner, the compression engine 212 compresses and transfers the hypermedia input 202 through the bus 214 for storing in the storage 222 while the media editor 210, which performs non-linear editing functions, advantageously provides for the output and manipulation of the hypermedia input 202. The processor 218 administers access to the bus 214 and to the storage 222 and uses the memory 220 as a local storage area for program instructions and as a buffer for data. Thus, the media editor 210 communicates with the processor 218 and the storage 222 via the bus 214. The processor 218 also supports communication interfaces (not shown), such as SCSI ports, serial ports, parallel ports, IrDA compliant infrared ports, USB ports, Musical Instrument Digital Interfaces (MIDI), PCMCIA/PC Card interfaces, IEEE 1394 Firewire and Smart Card interfaces, for additional network and hypermedia devices.

In one presently preferred embodiment, the compression engine 212 provides data compression and decompression using wavelet techniques. In another preferred embodiment, the compression engine 212 provides data compression and decompression using discrete cosine transform (DCT) techniques, such as JPEG, MPEG-1, MPEG-2 and MPEG-4. Similarly, the processor 218 preferably comprises a conventional embedded controller, such as a Hitachi SH7032, IBM PowerPC 403 or an Intel i860, although a general purpose microprocessor may be used. In

addition, the memory 220 may preferably be embodied as one or more of various types of electronic memory, such as DRAM, SRAM, ROM, EPROM, EEPROM and flash memory. Similarly, the storage 222 may preferably be embodied as one or more of various types of direct access non-volatile storage devices, such as magnetic, magneto-optic and optical disk drives. As is well known in the technology, the bus 214 comprises a set of conductors, or wires, for the transfer of data and addresses among the compression engine 212, the media editor 210, the processor 218 and the storage 222. In one presently preferred embodiment, the bus 214 operates at 33MHz and transfers 32 bits of information in each cycle.

The dual paths of the hypermedia input 202 enable simultaneous viewing and editing of hypermedia during capture. For example, a hypermedia input 202 comprising an MPEG compressed digital video bit stream is captured directly to the storage 222 by transfer through the bus 214 without modification by the compression engine 212 since the hypermedia input 202, an MPEG bit stream, is already compressed. In parallel, the media editor 210 concurrently receives the hypermedia input 202, determines the hypermedia input 202 is a compressed MPEG bit stream, and communicates with the compression engine 212 to decompress the MPEG bit stream for editing and output to an output device, such as a television set. In contrast to conventional personal computer expansion bus devices, the dual paths of the present invention eliminate the need to transfer large amounts of data from the storage 222 through the bus 214 to the media editor 210 during hypermedia capture. As a consequence, the dual path design likewise reduces the need for additional memory, bandwidth and processor computing power, thereby reducing system cost substantially.

II. The Media Editor

Referring now to Figure 6, a block diagram illustrates the architecture of the media editor 210. As discussed above, hypermedia input 202 (Figure 5) is simultaneously compressed to the storage 222 while streaming to the media editor 210 via a video controller 252. To prevent displayed images from jumping when viewed, the video controller 252 synchronizes the video output signals independently of the input video signals. Thus, the input horizontal and input vertical synchronization signals fed across lines 254, 256 are not used to control the output horizontal and output vertical synchronization signals fed across lines 258, 260. However, independent frame synchronization often results in a "tearing" distortion of unmanipulated, or pass-through, video images. The present invention eliminates "tearing" distortions through a design whereby hypermedia input 202 and hypermedia output 208 share the same master pixel clock 250. Thus, the media editor 210 produces a stable video output from the video portion of a hypermedia input 202, which may include unstable and distorted feeds from multiple, unsynchronized, real-time video sources.

The video controller 252 provides the video portion 262 of the hypermedia input 202 to a programmable low-pass filter 264, such as a Faraday FL676 or a Micro Linear ML6420, to remove high frequency aliasing components so as to form a filtered video signal 266. In turn, the filtered video signal 266 is fed to a programmable video scaler 268, such as a Phillips SAA 7140A or SAA 7186. The filtered video signal 266 improves the output quality of the video scaler 268, which enables resizing of a video image frame to a selected size for viewing and editing. In contrast to the RGB color signals of the prior art, the video scaler 268 outputs a scaled YUV video signal

comprising a luminance signal 270 and two color difference signals 272, 274. A gamma corrector 276 receives the signals 270, 272, 274 and performs gamma correction for the non-linear illumination of cathode ray tube (CRT) displays in addition to various color effects, such as posterization, negative imagery, tints and enhancements. In a preferred embodiment, the gamma corrector 276 is implemented as a lookup table in semiconductor memory. The resulting gamma corrected signals 278 are fed to a first-in, first-out (FIFO) buffer 280, then to an input frame controller 282, which assembles gamma corrected signals 278 into a video frame 284. A memory controller 286 receives and transfers the video frame 284 to the media buffer 216 (Figure 5) for rapid access by the media editor 210. In contrast to conventional memory controllers for PC based non-linear editing systems, which access multiple devices using a wide variety of fetches, such as cache burst, DMA, and CPU instruction or data fetches, the memory controller 286 of the present invention is preferably optimized for multiple sequential fetches of large memory blocks.

To perform a transition between a first and a second sequence of frames using a selected first frame and a selected second frame, each representing their respective frame sequences, the input frame controller 282 stores the first frame selected from the first frame sequence in a first location of the media buffer 216. Similarly, the input frame controller 282 stores the second frame selected from the second frame sequence in a second location of the media buffer 216. In response to the consumer's input, the non-linear editor 200 (Figure 5) creates an alpha frame, which describes how to combine the first and second frames so as to form the transition, and stores the alpha frame in a third location of the media buffer 216. An alpha frame is a video frame including an alpha value for each pixel, instead of a pixel value representing a color in a conventional video frame. The alpha value defines a mix level between corresponding pixels of the first and second frames. A SCRAM engine 288 retrieves the first frame, the second frame and the alpha frame from the media buffer 216. Upon retrieving these frames, the SCRAM engine 288 forms a transition frame, on a pixelated basis, by combining the pixels of the first, second and alpha frames according to the equation:

> Transition Frame pixel = [(First Frame pixel * Alpha Frame pixel) + Second Frame pixel * (1 - Alpha Frame pixel)],

where each pixel in an alpha frame is normalized to a value between zero and one inclusive. Lastly, the SCRAM engine 288 provides the transition frame to the memory controller 286. The memory controller 286 may transfer the transition frame to the media buffer 216 (Figure 5) or to the compression engine 212 (Figure 5), which compresses the transition frame data for subsequent transfer to the bus 214 (Figure 5) for capture in the storage 222 (Figure 5). In a preferred embodiment, the media editor 210 includes the Applied Magic Video Processor.

A consumer may set the pixel values for any of the first, second and alpha frames equal to a constant, indicating a single color for the entire frame. In response, the SCRAM engine 288 does not retrieve the frames, but instead uses the specified constant values to calculate the transition frame. For example, the transfer of an alpha frame typically requires a 10 Megabyte/sec bandwidth and the transfer of a first or second video frame typically requires a 20 Megabyte/sec bandwidth. To reduce bandwidth and media buffer memory, the SCRAM engine 288 uses a single constant value for transitions, such as a dissolve or fade between a first and second frame sequence, requiring the same constant value for each pixel of the alpha frame. Thus, instead of using 10 Megabytes/sec of

bandwidth to transfer alpha frame data, the SCRAM engine 288 uses only 30 bytes/sec for NTSC video or 25 bytes/sec for PAL video. Similarly, for a fade to black, the SCRAM engine 288 uses single constant values for both the alpha frame and the second frame to avoid the use of a further 20 Megabytes/sec of bandwidth to transfer pixel data for both the alpha frame and the second frame. Moreover, in a preferred embodiment, reductions in the bandwidth requirements of the present invention enable the use of a media buffer 216 (Figure 5) comprising inexpensive DRAM, instead of expensive dual port video RAM (VRAM).

To play back video transitions, an alpha playback controller 290 communicates a fetch request to the memory controller 286 to retrieve selected alpha frames from the media buffer 216 (Figure 5). The alpha playback controller 290 provides the retrieved alpha frames to a Video Arithmetic Logic Unit (ALU) 292 to combine with the first and second frames so as to form transition frames. In a similar manner, a first playback controller 294 and a second playback controller 296 simultaneously retrieve the first and second frames from the media buffer 216 through the memory controller 286. The retrieved frames are buffered in corresponding FIFOs 298, 300, 302 for ready access by the Video ALU 292. The Video ALU 292 uses the retrieved alpha frames to combine the first and second frames retrieved so as to form a transition frame for output to an encoder 206 (Figure 5) or to a viewing device. Moreover, for unmodified video, the present invention likewise reduces playback bandwidth and eliminates unnecessary memory fetches by disabling the second playback controller 296 and the alpha playback controller 290 to free up 30 Megabytes/sec of bandwidth for other system uses. A similar 30 Megabyte/sec bandwidth reduction would result from fade to black during playback. The alpha playback controller 290 enables more complex playback features, such as real-time rendering of flying or scrolling text overlays, moving pre-rendered graphical objets onto an image from a variety of hypermedia sources, and providing on-screen controls on top of the playing video. The Video ALU 292 receives input from three real-time video paths, the master pixel clock 250, an alpha path having mixing information for two full color video input paths, and serves as the primary video output of the media editor 210.

The media editor 210 also provides for the playback, capture and mixing of multiple audio channels, each channel having a left and right input with individual volume controls. An audio codec interface 304 receives the audio portion of the hypermedia input 202 (Figure 5) and outputs the audio portion of the hypermedia output 208 (Figure 5). The audio codec interface 304 buffers audio samples for playback of all audio channels to an audio write FIFO 306. An audio write controller 308 transfers audio samples retrieved from the audio write FIFO 306 to the memory controller 286 for storage in contiguous memory locations in the media buffer 216 (Figure 5) or in the storage 222 (Figure 5) by transfer through the bus 214. To play back captured audio samples, an audio read controller 310 retrieves selected audio samples from the media buffer 216 (Figure 5) or the storage 222 (Figure 5) by issuing a fetch request to the memory controller 286. The audio read controller 310 buffers retrieved audio samples in an audio read FIFO 312, which communicates with an audio mixer 314, wherein volume information for each channel is added to audio samples retrieved from the audio read FIFO 312. Lastly, the audio mixer 314 provides a mixed audio sample having channel volume information to the audio codec interface 304, which synchronizes the mixed audio sample with video for output using the master pixel clock 250.

The memory controller 286 manages the interface between the media editor 210 and the media buffer 216. In a preferred embodiment, the media buffer 216 comprises dynamic RAM (DRAM) memory, instead of costly dual port video RAM (VRAM). To satisfy DRAM timing and access constraints, the memory controller 286 provides arbitrated burst access to the media buffer 216 from the media editor 210. As multiple controllers within the media editor 210 access the media buffer 216, the memory controller 286 uses bank interleaving to improve access performance by avoiding page misses. Bank interleaving exploits the performance of the DRAM memory. By allocating video frames in a selected order, the memory controller 286 can perform fetches without page misses. One embodiment of a bank interleaving scheme which eliminates page misses and optimizes use of available memory bandwidth is as follows:

1. Activate memory bank 0 with a row address from the alpha playback controller 290;

2. Burst read the alpha frame data while activating Bank 1 with a row address from the second playback controller 296 for second frame data;

3. Interrupt the transfer to the alpha playback controller 290 after 'x' cycles to transfer second frame data to the second playback controller 296; activate bank 0 again with a row address from the first playback controller 294;

4. Burst read second frame data for '2x' cycles;

5. Burst read first frame data for '2x' cycles.

Note that a bank interleaving scheme optimized to avoid page misses is dependent upon the number of concurrent active memory accesses. In a preferred embodiment, the memory controller 286 locates video frame data within the media buffer 216 so as to avoid page misses when retrieving video frame data. Moreover, the memory controller 286 prioritizes access to the media buffer 216. For example, when the alpha playback controller 290, the first playback controller 294, the second playback controller 296 and the input frame controller 282 require real-time access, the memory controller 296 sets the access priorities so as to ensure that each controller receives its data when needed. The memory controller 286 is preferably programmable so that the priority of access for each operational mode is selectable. Lastly, due to the relatively small bandwidth for audio access as compared to video access, the audio read controller 308 and the audio write controller 310 may access the media buffer 216 at all times.

III. Operation of the Non-Linear Editing System

A consumer may use the non-linear editing system 100 (Figure 1) to capture, manipulate, interact with, transport and play back hypermedia from a plurality of concurrent, independent hypermedia sources. Figure 7 illustrates a method of operating the non-linear editing system 100. At state 360, a consumer initializes the system 100 by powering on the main unit 122 (Figure 1). In a preferred embodiment, the consumer depresses the "On" button of the remote control 124 (Figure 1). During initialization, the system 100 may perform a power on self test (POST) to determine if all of its components, such as the memory 220 (Figure 5), are functioning properly. Additionally, the processor 218 (Figure 5) loads an embedded operating system, preferably the Microware OS9000

for the IBM PowerPC 403, and software instructions for the GUI and non-linear editing functions from the memory 220. In a preferred embodiment, the software instructions for the non-linear editing system 100 are stored in a programmable control ROM portion of the memory 220. In contrast to prior art systems, previously captured data is automatically loaded at state 362. Moreover, at state 362, the system 100 is preferably restored to its condition immediately prior to the last power down. Advantageously, a consumer may proceed with all tasks in progress as if the system 100 had not been powered down. At state 364, a determination is made whether to capture new data. If new data is not desired, the system 100 provides a storyboard having previously captured data at state 372, wherein a consumer may edit and play back the storyboard. A storyboard is a sequential representation of a clip having video, audio, stills, effects and other hypermedia, presented as a picture icon. The sequence runs from left to right in a top to bottom order. If new data is desired, the system 100 checks the storage 222 (Figure 5) for available space at state 366. If there is no available space in the storage 222, the system proceeds to state 368 to make space available. Otherwise, the system 100 captures hypermedia at state 370 and proceeds to state 372 where the system 100 automatically provides a storyboard having the captured hypermedia. Lastly, at state 374, a consumer may create a copy of a storyboard to a recordable DVD or videotape.

Referring now to Figure 8, a flowchart illustrates a method for manipulating hypermedia. At state 380, a consumer captures hypermedia to a storyboard. The storyboard often includes a plurality of captured hypermedia portions, or clips. At state 382, the consumer manipulates the captured hypermedia on the storyboard. The non-linear editing system 100 (Figure 1) preferably includes selected default transitions between each pair of clips automatically. For example, consumers manipulate clips by enhancing them with graphics, text and audio annotations. Consumers may likewise enhance electronic mail (e-mail) by excerpting, editing and attaching the edited clips to their e-mail messages. Consumers also manipulate clips by compiling a sequence of clips and creating the transitions between each pair of clips. Additionally, consumers may manipulate clips by incorporating digitized photographs, synchronized music and other forms of digital hypermedia captured from the Internet via the Internet browser functionality incorporated into the non-linear editing system 100. For example, a consumer may manipulate a clip by excerpting a video still or a digital photograph from a clip for placement on a World Wide Web page or print out as a photograph or postcard. At state 384, the consumer may modify the default transitions selected by the non-linear editing system 100. Moreover, at state 386, the system 100 enables consumers to add overlays, such as graphical and audio annotations of clips. Lastly, consumers may play back their storyboards at state 388 or copy their storyboards at state 390. Consumers preferably copy the hypermedia represented by storyboards to videotape machines, such as a VCR or camcorder.

Figure 9 illustrates an embodiment of a graphical user interface 400 useful for the capture of hypermedia. The capture GUI 400 provides a plurality of tabs 402 enabling selection of various functions of the non-linear editing system 100. In capture mode, the capture GUI 400 preferably includes a shot tab 404 displaying icons 406 representing previously captured clips. The capture GUI 400 likewise includes a display window 408 to display an image from a clip referenced by a selected icon 410. Moreover, the capture GUI 400 includes a control panel 412 displaying a plurality of buttons 414 representing capture functions, such as record, play, stop and pause. Similarly,

the capture GUI 400 provides for the selection of capture properties using at least one drop down menu 416. For example, using the drop down menu 416, a consumer may instruct the non-linear editing system 100 to capture from a VCR to Storyboard 1 as illustrated in Figure 9. The capture GUI 400 may also include a selection box 418 to specify hypermedia data types to capture as well as an entry box 420 to specify a clip name. The capture GUI 400 may additionally include a quality window 422 having a slide bar 424 and a slider 426. The consumer selects the capture quality by manipulating the slider 426 within the slide bar 424. Lastly, the capture GUI 400 includes an icon bar 428 having icons representing the different modes of the non-linear editing system 100. The consumer manipulates the capture GUI 400 using the point and click functionality of the pointing device 134 (Figure 2b) to select and manipulate items within the capture GUI 400 in coordination with the keyboard 130 (Figure 2b) to provide keyboard inputs as needed.

Figure 10 illustrates an embodiment of a storyboard GUI 440. As discussed previously, the storyboard GUI 440 includes a shot tab 404 displaying icons 406 representing previously captured clips. The storyboard GUI 440 likewise includes a display window 408 to display an image from a clip referenced by a selected icon 410. In addition, the storyboard GUI 440 includes a plurality of storyboard tabs 442, each tab referencing a selected storyboard having a sequence of clips with transitions. For example, a vacation tab 444 includes a vacation storyboard 446 having six clips, corresponding to the image icons, and five transitions, one transition between each pair of clips. The vacation storyboard 446 includes a time ruler 448 having a graphics bar 450, a first audio bar 452 and a second audio bar 454. The bars 450, 452, 454 indicate the name and duration of the hypermedia portion corresponding to the clip represented by the icon above the bar. Each of the storyboard tabs 442 includes a scroll bar 456 to scroll down the window illustrating the storyboard corresponding to the selected tab. To add a clip to a storyboard, the consumer selects the shots tab 404 and one of the storyboard tabs 442 of interest, such as the vacation tab 444, to display the storyboard 446. The consumer then selects, drags and drops a clip icon 410 onto the storyboard 446 as shown in Figure 10. The non-linear editing system 100 automatically provides a default transition on the storyboard immediately prior to the newly added clip 410. Lastly, the storyboard GUI 440 includes a button panel 458 having a plurality of buttons corresponding to a wide variety of editing functions for the storyboard 446, such as save, print, cut, copy and paste. A consumer may edit a storyboard 446 using the point and click functionality of the storyboard GUI 440 in conjunction with the functions corresponding to buttons comprising the button panel 458.

The storyboard GUI 440 preferably displays the sequence of items on a storyboard instead of their absolute time scales. Thus, icons of a single size represent each captured clip, regardless of its actual duration. However, other data on the storyboard associated with a captured clip is represented by an indicator having a size and location corresponding to the temporal relationship with the captured clip. For example, an audio clip having a duration of half the length of a captured clip appears on a first 452 or second 454 audio bar under the icon of the captured clip with an indicator bar half the length of the icon. Moreover, for a half length audio clip synchronized to begin at one quarter of the clip duration, the indicator bar appears indented one quarter of the icon width from both sides, corresponding to a start at one quarter clip duration and a termination at three quarter clip duration. Thus, the time

ruler 448 of the present invention, referred to as a cartoon timeline, illustrates the sequential relationship of events. Advantageously, the cartoon timeline metaphor eliminates the need for consumers to zoom in on various portions of the storyboard to identify and manipulate clips, thereby improving the usability of a storyboard GUI 440. Similarly, the cartoon timeline metaphor of the present invention eliminates the need for a high resolution computer graphics monitor as a high quality image of the storyboard GUI 440 can be rendered on a conventional television set. Moreover, the cartoon timeline metaphor eliminates the need to render a minute sliver of an icon, representing a captured clip of extremely short duration, on a low resolution television screen for consumer viewing from relatively large distances. Lastly, in contrast to prior art systems, the cartoon timeline metaphor of the present invention illustrates the relationship between associated data, such as audio and graphical annotations, and the captured clips through indicator bars, which are relative in nature as opposed to absolute in time.

Figure 11 illustrates an embodiment of a transition GUI 470. As shown in the storyboard GUI 440 (Figure 10), the transition GUI 470 includes a vacation tab 444 having a vacation storyboard 446 and a button panel 458 having a plurality of buttons corresponding to editing functions. In the transition GUI 470, the transitions tab 472 is selected to display a plurality of icons 474, each icon representing a predetermined transition effect. As before, to change a transition, the consumer selects, drags and drops a desired transition icon 476 on the storyboard 446 at a location between a pair of clips. The consumer may likewise edit the transitions of a storyboard 446 using the point and click functionality of the transition GUI 470 in conjunction with the functions corresponding to button comprising the button panel 458. Note that the transitions tab 472 includes a scroll bar to scroll down the window illustrating the icons corresponding to various transition effects.

Figure 12 illustrates an embodiment of a graphics GUI 490. The graphics GUI 490 includes a graphics tab 492 having a scroll bar 494 and a plurality of icons 496 representing various graphics overlays, such as color, titles, and text on color. The graphics GUI 490 similarly includes a display window 408 to display an image for graphical editing. The graphics GUI 490 also includes an image edit window 498 having a plurality of image editing tool buttons 500, such as a line tool, a box tool, a text tool, cut, copy and paste, about the periphery of the image edit window 498. As before, a consumer uses the point and click functionality of the remote control 124 (Figure 2b) to select and manipulate the image editing tool buttons 500. Moreover, the graphics GUI 490 includes a features portion 502. The features portion 502 includes an name box 504, wherein the consumer may select a name to identify the edited graphic and a plurality of tabs 506, each tab having property selections for some of the image editing tool buttons 500. For example, a color tab 508 includes selection boxes 510 to select color features of lines, fills and shadows. Lastly, the features portion 502 includes a pair of slider bars 512, each having a slider 514, for the selection of color gradients. Operation of the graphics editor is similar to conventional graphics editors, such as MacPaint and Paintbrush.

Each major element of the GUI is derived from a list of consumer tasks. Figure 13 is a task flow diagram 550 illustrating the manipulations a consumer may perform with the non-linear editing system 100. Each of the illustrated tasks is intra-cyclical in nature, meaning that a consumer may perform the task over and over until satisfied with the results. Note that illustrated tasks are also inter-cyclical in that a consumer may pass forward

and back to other tasks. As discussed previously, the software functionality for carrying out the tasks is located in the processor 218 (Figure 5), which loads the software instructions from the memory 220 (Figure 5). At initialization, the system automatically loads previously captured hypermedia portions from the storage 222 (Figure 5) and places them into a storyboard so that a consumer may create an edited storyboard. At task 552, a consumer may capture, or digitize for storage, hypermedia portions, or shots, from a hypermedia source. Ultimately, the hypermedia shots are stored in the storage 222 (Figure 5). During this task, a consumer may perform some "rough" editing by electing not to digitize selected portions that they do not wish to include in the finished master. At task 554, the consumer places captured shots on the storyboard. The storyboard may be thought of as a working portion of the media buffer 216 (Figure 5). As discussed previously, shots are automatically placed into the storyboard in the order in which they were captured. Similarly, when shots are placed into the storyboard, transitions between shots are automatically generated. At task 556, the consumer may perform "fine" editing of shots, such as moving, duplicating, removing and manipulating the duration of shots. For example, in a storyboard having 5 shots with 4 interposed transitions, a consumer may move the first shot to the end, whereby the system automatically removes the transition between the first and second shots and adds a default transition between the end shot and the first shot. The consumer may likewise modify the transitions at task 558 and annotate shots with overlays, such as graphics and audio, at task 560. Moreover, the consumer may playback the storyboard at task 562 or may save a copy of the storyboard at state 564. When the consumer has completed all desired tasks on this storyboard, the consumer may create another storyboard at task 566.

Figure 14 is a diagram illustrating the GUI display flow. The GUI is implemented by a non-linear or event based software application. In traditional user interface development, the diagram would represent the menu structure of the application. However, in a presently preferred embodiment, the first layer 580 identifies the major system functions represented by icons 428 (Figure 9). The second layer 582 identify further functions and features corresponding to the major system functions of the first layer 580. The capture function 584 provides tools to capture from a variety of hypermedia sources, such as a camcorder 586, a VCR 588 and a digital camera 590. The storyboard function 592 provides tools to edit, playback and record shots. Storyboard tools include graphics 594, transitions 596 and effects 598. The paint box function 600 provides additional editing tools for drawing 602, character generation 604, video underlay 606 and still photo underlay 608. The Internet function 610 includes tools for e-mail 612 and a browser plug-in 614, wherein commercially available browsers, such as Internet Explorer and Netscape Navigator, may be integrated. A consumer may add, remove, change or otherwise manipulate hyperlinks using the browser. The set-up function 618 enables configuration of the system by providing tools to indicate preferences 620 and software installation/removal tools 622. The extras function 624 provides extendibility tools to supplement and extend system functions. Lastly, the help function 628 provides tools to access system help documentation.

All objects, such as shots, audio, graphics and transitions, can be manipulated by initiating a details display from the button panel 458 (Figure 10) after selecting the desired object from the storyboard. The consumer can play the edited hypermedia in a playback area or full screen at any time during the editing process, and when

satisfied, the consumer may record the edited hypermedia to an output device, such as a recordable DVD or VCR, by selecting the Select All button on the storyboard display and then selecting the Master button. Thus, rather than a delivery only system for hypermedia, the present invention allows the consumer to, for example, download hypermedia from the Internet and edit or manipulate it through the storyboard program.

IV. Summary

The present invention provides a complete, standalone, economical system that enables consumers to create, manipulate, edit, view and output hypermedia in their homes. In contrast to the prior art, the non-linear editing system of the present invention does not require a consumer to incur substantial expenses to purchase a personal computer having expansion bus add-in cards and software to capture and edit hypermedia in their homes. Similarly, unlike current personal computers, the present invention is adapted for communication with conventional home entertainment components, such as a VCR, television, stereo, camcorder and digital still camera. Moreover, the non-linear editing system of the present invention provides for a wide variety of hypermedia output mediums, such as computer displays, television, printers, videotapes, DVDs, and audio speakers.

In addition, the present invention advantageously overcomes the expense and complexity of prior art non-linear editing systems by providing an inexpensive and easy to learn system for home use. Unlike conventional non-linear editing systems designed for professional use, the present invention automatically loads previously captured data onto the storyboard for editing. Similarly, the present invention automatically provides default transitions between each pair of clips on the storyboard. The present invention thus simplifies and facilitates the editing of home movies by enabling consumers to immediately manipulate captured clips, instead of undertaking complicated tasks to configure the storyboard as required by conventional non-linear editing systems. The present invention likewise provides novel methods of data handling to reduce bandwidth requirements and leverages the availability of low cost components to perform the functions of the costly, specialized components of the prior art. The media editor of the present invention combines the functions of various prior art software and hardware components into a novel architecture, which is integrated onto a low cost application specific integrated circuit (ASIC). The novel architecture of the present invention permits the use of inexpensive DRAM to create hypermedia effects using multiple video and analog channels simultaneously. In contrast to costly prior art VRAM buffers, the media editor of the present invention provides for priority based interleaved access to a DRAM based media buffer that delivers full video bandwidth. Additionally, the system accepts a wide variety of hypermedia data types and stores them in the same storage, enabling the mixing of audio, video, text, music and other data types using common mixing engines. Moreover, the system allows for the capture of multiple hypermedia channels with simultaneous playback and editing. Furthermore, because the hypermedia output is not dependent on the hypermedia input synchronization, hypermedia inputs may be removed, attached and switched on the fly, resulting in different hypermedia input synchronizations without any effect on the timing or quality of the hypermedia output. Lastly, audio is synchronized to video by reference to a master pixel clock, which is also used to prevent "tearing" and other distortions.

The invention may be embodied in other specific forms without departing from its spirit or essential characteristics. Thus, the described embodiments are, in all respects, merely illustrative and not restrictive.

Moreover, the appended claims, rather than the foregoing description, serve to define the scope of the invention. These claims embrace within their scope all changes which come within their meaning and range of equivalency.

WHAT IS CLAIMED IS:

1. A non-linear editing system, comprising:

a remote control to provide command signals;

a main unit, responsive to the command signals, having a non-linear editor to receive, access, and edit hypermedia and a direct access storage device to capture the hypermedia; and

an output device in communication with the main unit to receive and play the hypermedia.

2. The non-linear editing system of Claim 1, wherein the remote control comprises:

a power system;

a keyboard having at least one button; and

a keyboard processor in communication with the keyboard and receiving power from the power system, wherein the keyboard processor receives and converts input from the keyboard into the command signals.

3. The non-linear editing system of Claim 2, further comprising at least one pointing device in communication with the keyboard processor, wherein the keyboard processor receives and converts input from the at least one pointing device into the command signals.

4. The non-linear editing system of Claim 3, wherein the at least one pointing device may be configured to operate as a jog/shuttle wheel and wherein the keyboard processor receives and converts input from the jog/shuttle wheel into the command signals.

5. The non-linear editing system of Claim 2, further comprising a jog/shuttle wheel in communication with the keyboard processor, wherein the keyboard processor receives and converts input from the jog/shuttle wheel into the command signals.

6. The non-linear editing system of Claim 2, further comprising a wireless transmitter in communication with the keyboard processor, wherein the keyboard processor provides the command signals to the wireless transmitter for conversion into a wireless command signal.

7. The non-linear editing system of Claim 1, wherein the output device comprises a television set.

8. The non-linear editing system of Claim 1, wherein the output device comprises a computer display.

9. The non-linear editing system of Claim 1, wherein the output device comprises a videotape recorder.

10. The non-linear editing system of Claim 1, wherein the output device comprises at least one speaker.

11. The non-linear editing system of Claim 1, wherein the output device comprises a recordable CD-ROM.

12. The non-linear editing system of Claim 1, wherein the output device comprises a DVD.

13. The non-linear editing system of Claim 1, wherein the output device comprises a printer.

14. The non-linear editing system of Claim 1, wherein the main unit communicates with a network to access the hypermedia.

15. The non-linear editing system of Claim 14, wherein the network provides access to a real-time hypermedia source.

16. The non-linear editing system of Claim 14, wherein the network provides access to an off-line hypermedia source.

17. The non-linear editing system of Claim 14, wherein the network comprises a broadcast television network.

18. The non-linear editing system of Claim 14, wherein the network comprises a cable television network.

19. The non-linear editing system of Claim 14, wherein the network comprises a satellite television network.

20. The non-linear editing system of Claim 14, wherein the network comprises the World Wide Web portion of the Internet.

21. The non-linear editing system of Claim 1, wherein the main unit accesses the hypermedia from a videotape player.

22. The non-linear editing system of Claim 1, wherein the main unit accesses the hypermedia from a radio tuner.

23. The non-linear editing system of Claim 1, wherein the main unit accesses the hypermedia from a compact disc player.

24. The non-linear editing system of Claim 1, wherein the main unit accesses the hypermedia from a CD-ROM.

25. The non-linear editing system of Claim 1, wherein the main unit includes a communication port.

26. The non-linear editing system of Claim 25, wherein the communication port comprises an RS-232 serial port.

27. The non-linear editing system of Claim 25, wherein the communication port comprises a parallel port.

28. The non-linear editing system of Claim 25, wherein the communication port cmprises an IrDA compliant infrared port.

29. The non-linear editing system of Claim 25, wherein the communication port comprises a PCMCIA port.

30. The non-linear editing system of Claim 25, wherein the communication port comprises a USB port.

31. The non-linear editing system of Claim 25, wherein the communication port comprises a SCSI port.

32. The non-linear editing system of Claim 1, wherein the hypermedia is in a compressed digital data format.

33. A non-linear editor, comprising:

a bus;

a processor, in communication with the bus, to control access to the bus;

a memory in communication with the processor;

a compression engine, in communication with the bus, to compress and decompress hypermedia;

a storage, in communication with the bus, to capture and provide direct access to the compressed hypermedia; and

a media editor, in communication with the compression engine and the bus, the media editor and the compression engine receiving the hypermedia, wherein the media editor manipulates the hypermedia.

34. The non-linear editor of Claim 33, further comprising a decoder in communication with the compression engine and the media editor, wherein the decoder receives and decodes a hypermedia input so as to form the hypermedia.

35. The non-linear editor of Claim 34, wherein the decoder includes an analog to digital converter.

36. The non-linear editor of Claim 33, further comprising an encoder in communication with the media editor, wherein the encoder receives and encodes the hypermedia from the media editor so as to form a hypermedia output.

37. The non-linear editor of Claim 36, wherein the encoder includes a digital to analog converter.

38. The non-linear editor of Claim 33, further comprising a media buffer in communication with the media editor.

39. The non-linear editor of Claim 38, wherein the media buffer comprises dynamic random access memory.

40. The non-linear editor of Claim 33, wherein the processor comprises an embedded controller.

41. The non-linear editor of Claim 33, wherein the memory includes a read only memory device.

42. The non-linear editor of Claim 33, wherein the compression engine provides MPEG-1 compression and decompression.

43. The non-linear editor of Claim 33, wherein the compression engine provides MPEG-2 compression and decompression.

44. The non-linear editor of Claim 33, wherein the compression engine provides wavelet compression and decompression.

45. The non-linear editor of Claim 33, wherein the compression engine provides JPEG compression and decompression.

46. The non-linear editor of Claim 33, wherein the storage comprises a magnetic disk drive.

47. The non-linear editor of Claim 33, wherein the storage comprises a DVD device.

48. The non-linear editor of Claim 33, wherein the storage comprises a magneto-optic disk drive.

49. The non-linear editor of Claim 33, wherein the storage comprises a rewriteable optical disk drive.

50. A method of operating a non-linear editing system, comprising the steps of:

capturing hypermedia;

automatically loading the previously captured hypermedia; and

providing a storyboard to manipulate the previously captured hypermedia.

51. The method of Claim 50, further comprising the step of initializing the non-linear editing system.

52. The method of Claim 50, further comprising the step of making a copy of the storyboard.

53. The method of Claim 50, further comprising the steps of:

determining if a storage has space to capture a new hypermedia portion;

if the storage does not have space, making the space available in the storage; and

capturing the new hypermedia portion to the storyboard.

54. The method of Claim 50, wherein the step of automatically loading the previously captured hypermedia includes providing a default transition between a pair of previously captured hypermedia portions.

55. A method of editing hypermedia in a non-linear editing system, comprising the steps of:

capturing a plurality of hypermedia portions to a storyboard; and

automatically providing a transition between a pair of hypermedia portions within the plurality of hypermedia portions on the storyboard.

56. The method of Claim 55, further comprising the step of manipulating at least one of the plurality of hypermedia portions.

57. The method of Claim 55, further comprising the step of modifying the transition.

58. The method of Claim 55, further comprising the step of adding an overlay to at least one of the plurality of hypermedia portions.

59. The method of Claim 55, further comprising the step of playing back the storyboard.

60. The method of Claim 55, further comprising the step of copying the storyboard.

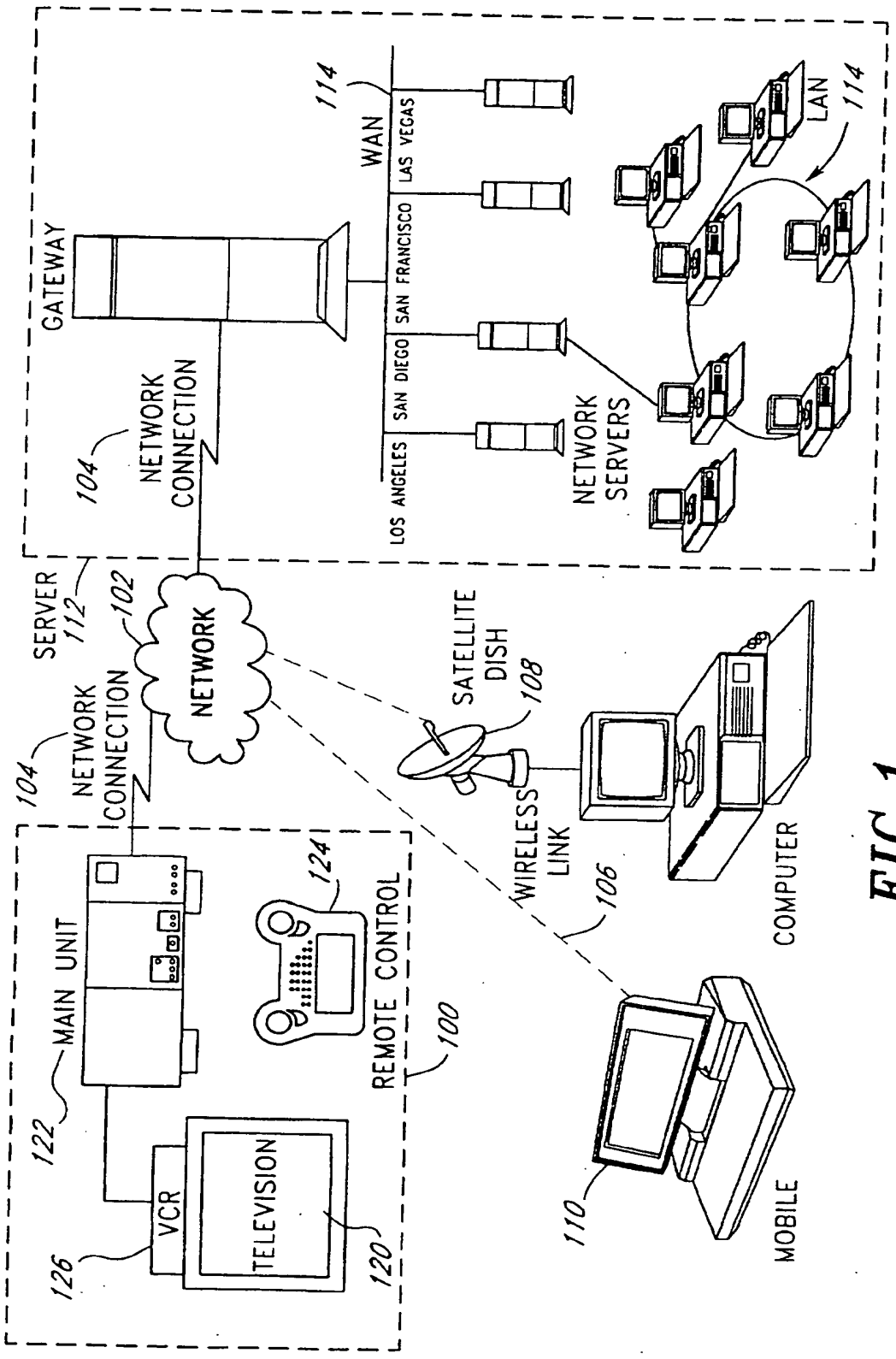
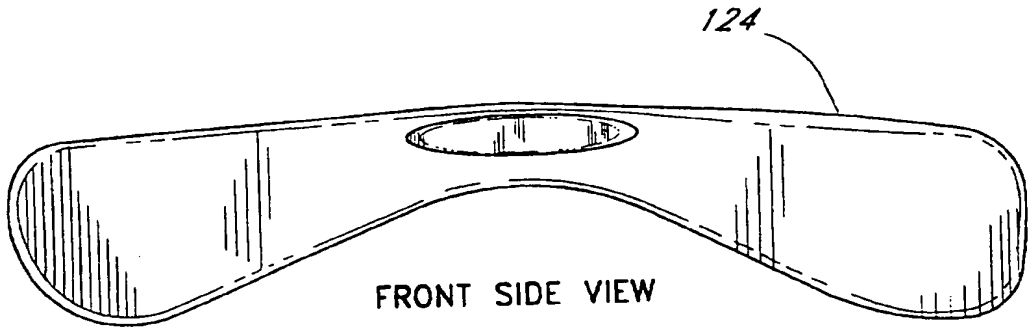
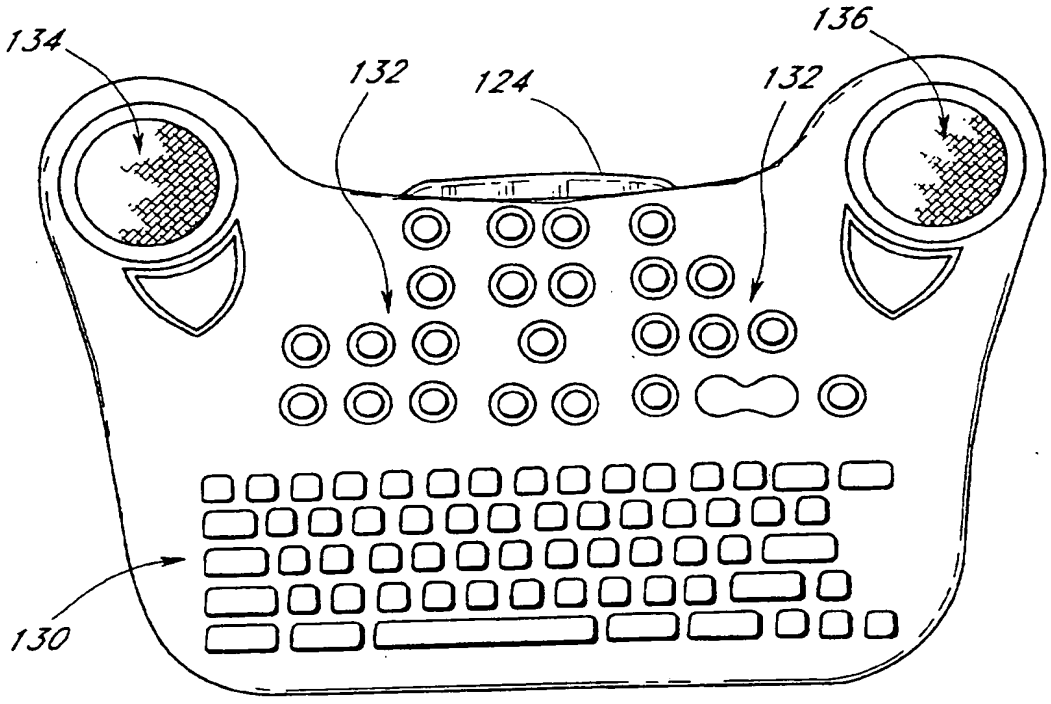

GATEWAY
NETWORK CONNECTION
104
WAN
114
LAS VEGAS
SAN FRANCISCO
SAN DIEGO
LOS ANGELES
NETWORK SERVERS
LAN
114
SERVER
112
102
NETWORK
SATELLITE DISH
108
104
NETWORK CONNECTION
WIRELESS LINK
106
COMPUTER
MAIN UNIT
122
124
REMOTE CONTROL
100
VCR
126
TELEVISION
120
110
MOBILE

FIG. 1



FRONT SIDE VIEW

Fig. 2a



TOP VIEW

Fig. 2b

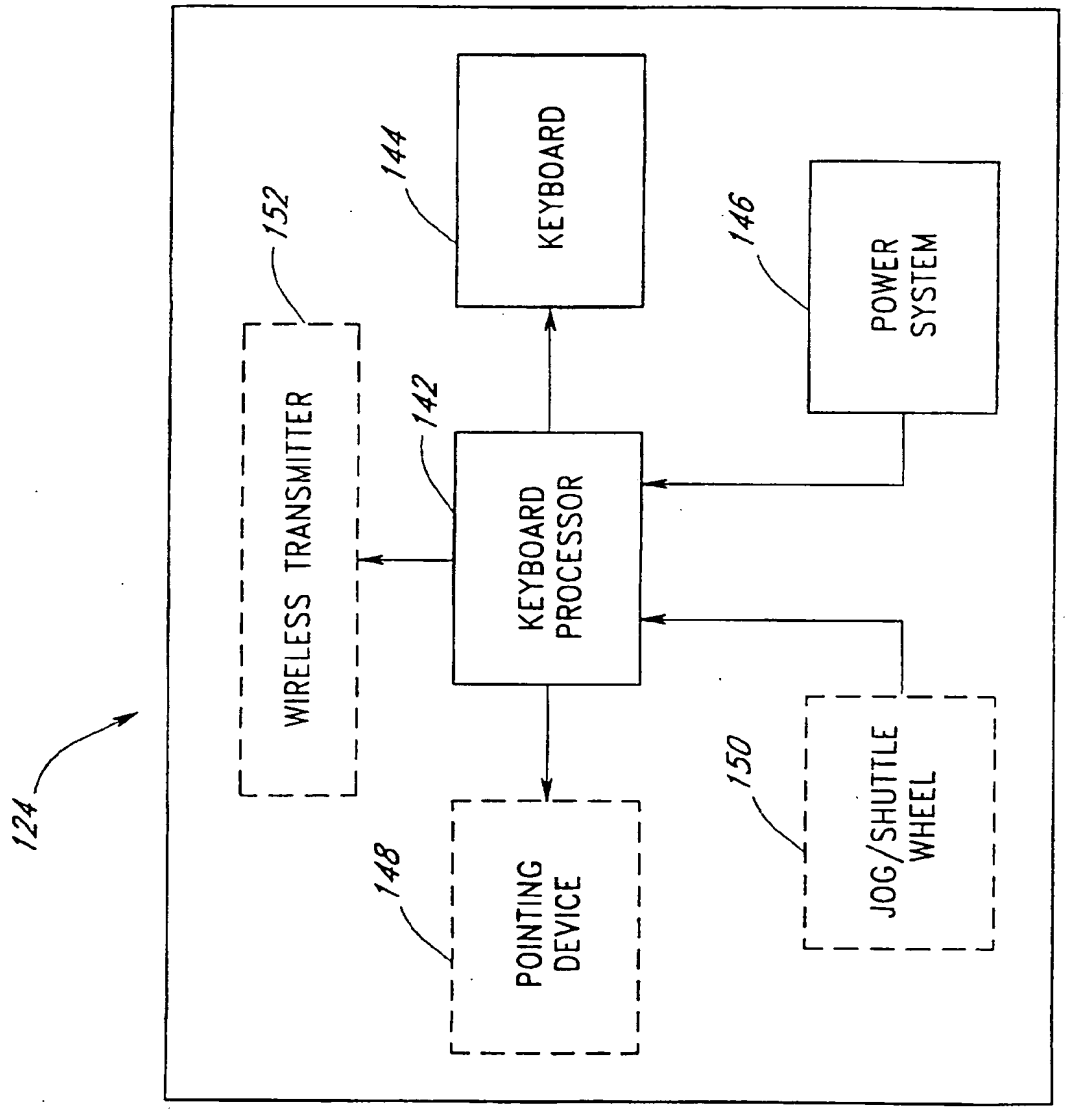

124
WIRELESS TRANSMITTER
152
KEYBOARD
144
KEYBOARD PROCESSOR
142
POWER SYSTEM
146
POINTING DEVICE
148
JOG/SHUTTLE WHEEL
150

Fig. 3

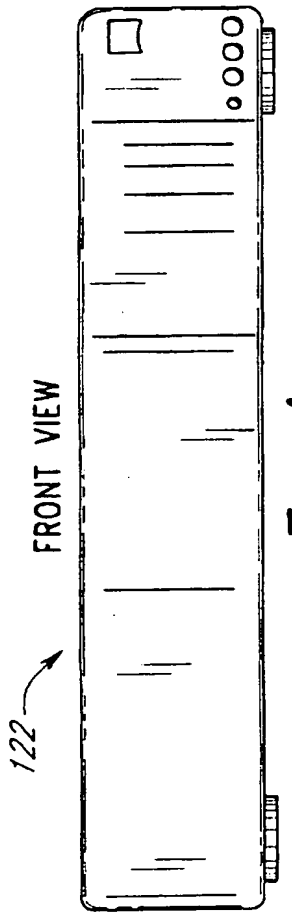


Fig. 4a

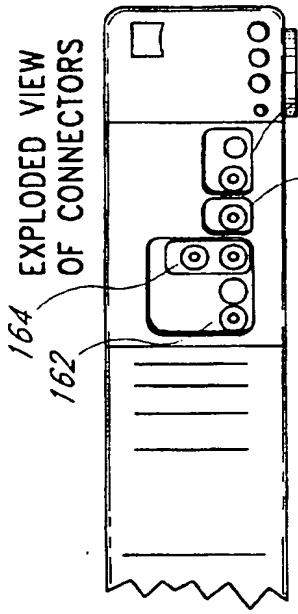


Fig. 4b

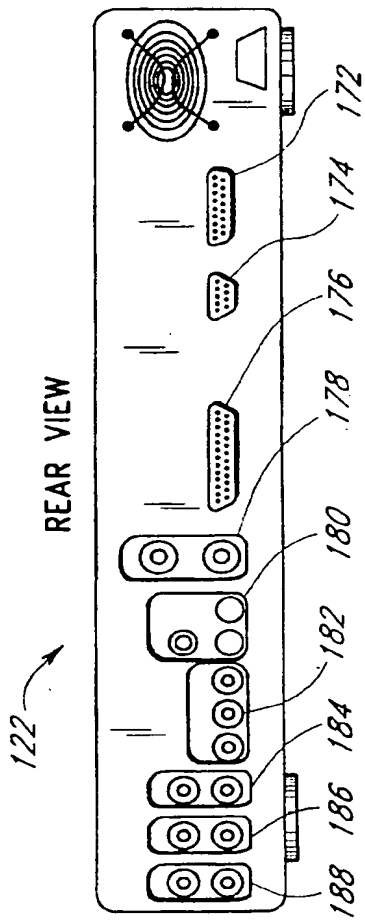


Fig. 4c

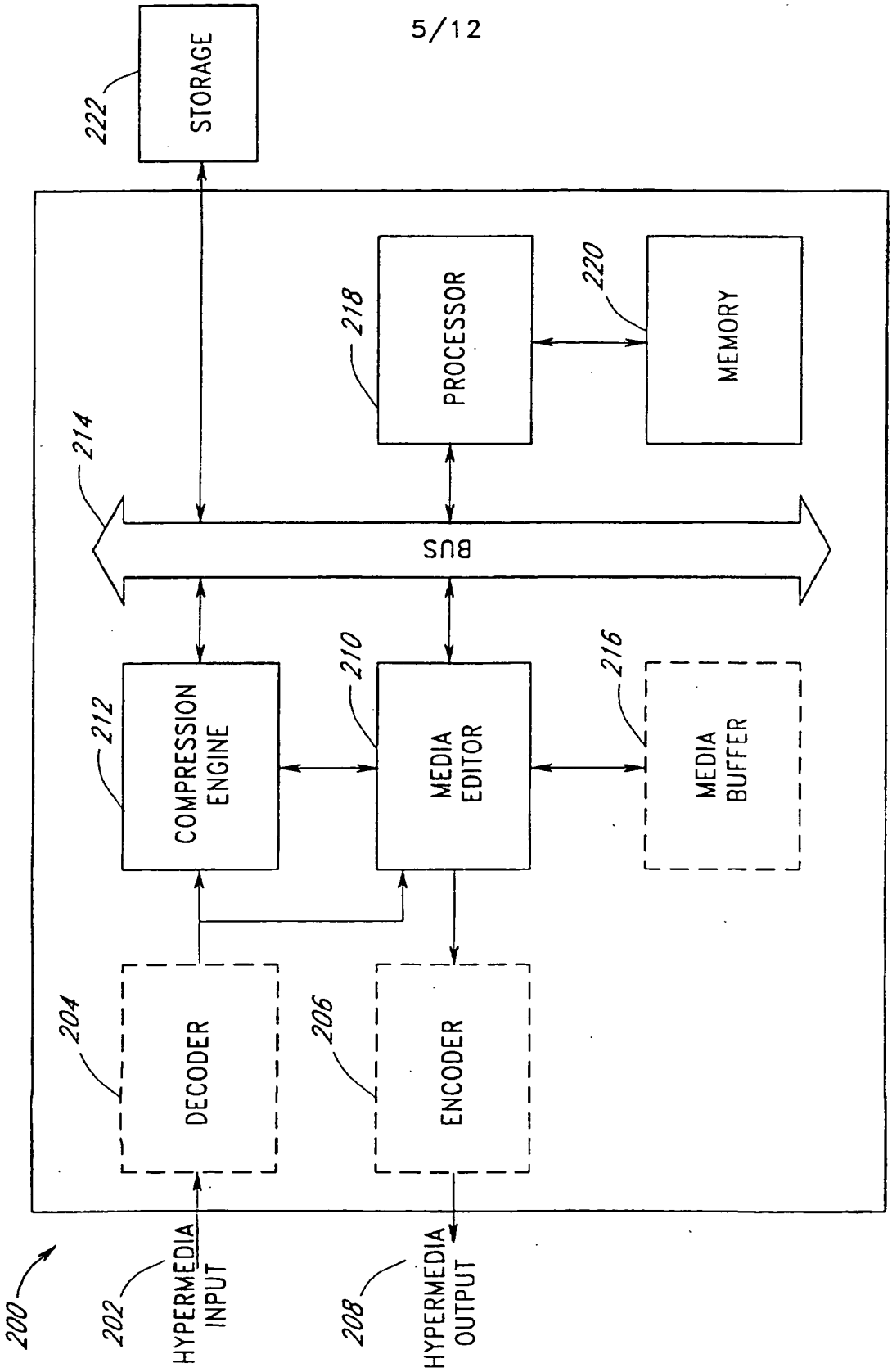

STORAGE
222
PROCESSOR
218
MEMORY
220
214
BUS
COMPRESSION ENGINE
212
MEDIA EDITOR
210
MEDIA BUFFER
216
DECODER
204
ENCODER
206
HYPERMEDIA INPUT
202
HYPERMEDIA OUTPUT
208
200
NON-LINEAR EDITOR

Fig. 5

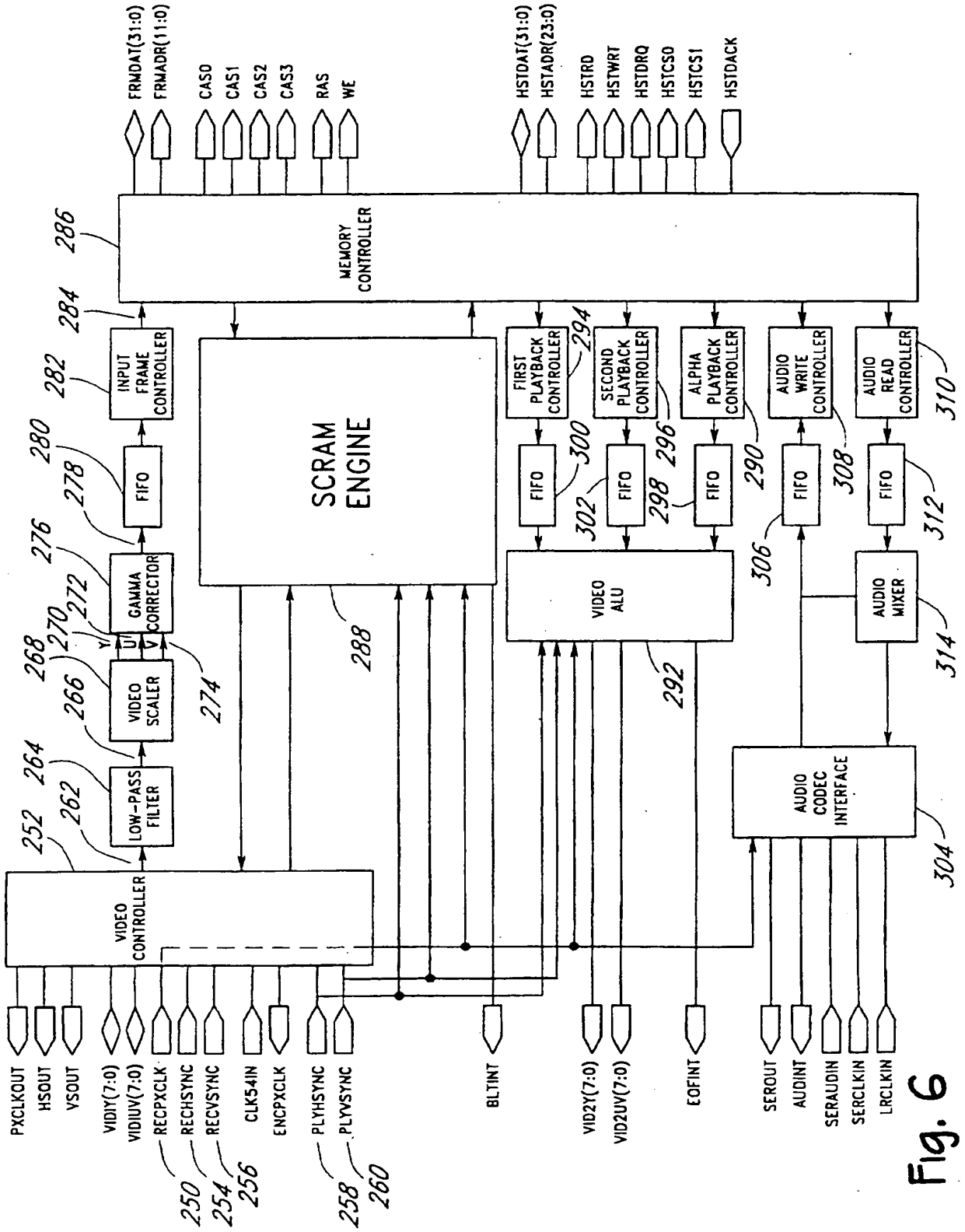

FRMDAT(31:0)
FRMADR(11:0)
CAS0
CAS1
CAS2
CAS3
RAS
WE
HSTDAT(31:0)
HSTADR(23:0)
HSTRD
HSTWRT
HSTDRQ
HSTCS0
HSTCS1
HSTDACK
MEMORY CONTROLLER
286
284
INPUT FRAME CONTROLLER
282
FIFO
280
278
GAMMA CORRECTOR
276
272
270
Y
U
V
VIDEO SCALER
268
266
274
LOW-PASS FILTER
264
262
252
VIDEO CONTROLLER
SCRAM ENGINE
288
FIRST PLAYBACK CONTROLLER
294
SECOND PLAYBACK CONTROLLER
ALPHA PLAYBACK CONTROLLER
AUDIO WRITE CONTROLLER
AUDIO READ CONTROLLER
310
300
296
290
308
312
FIFO
302
298
306
VIDEO ALU
292
AUDIO MIXER
314
AUDIO CODEC INTERFACE
304
PXCLKOUT
HSOUT
VSOUT
VIDIY(7:0)
VIDIUV(7:0)
RECPXCLK
RECHSYNC
RECVSYNC
CLK54IN
ENCPXCLK
PLYHSYNC
PLYVSYNC
250
254
256
258
260
BLTINT
VID2Y(7:0)
VID2UV(7:0)
EOFINT
SEROUT
AUDINT
SERAUDIN
SERCLKIN
LRCLKIN

Fig. 6

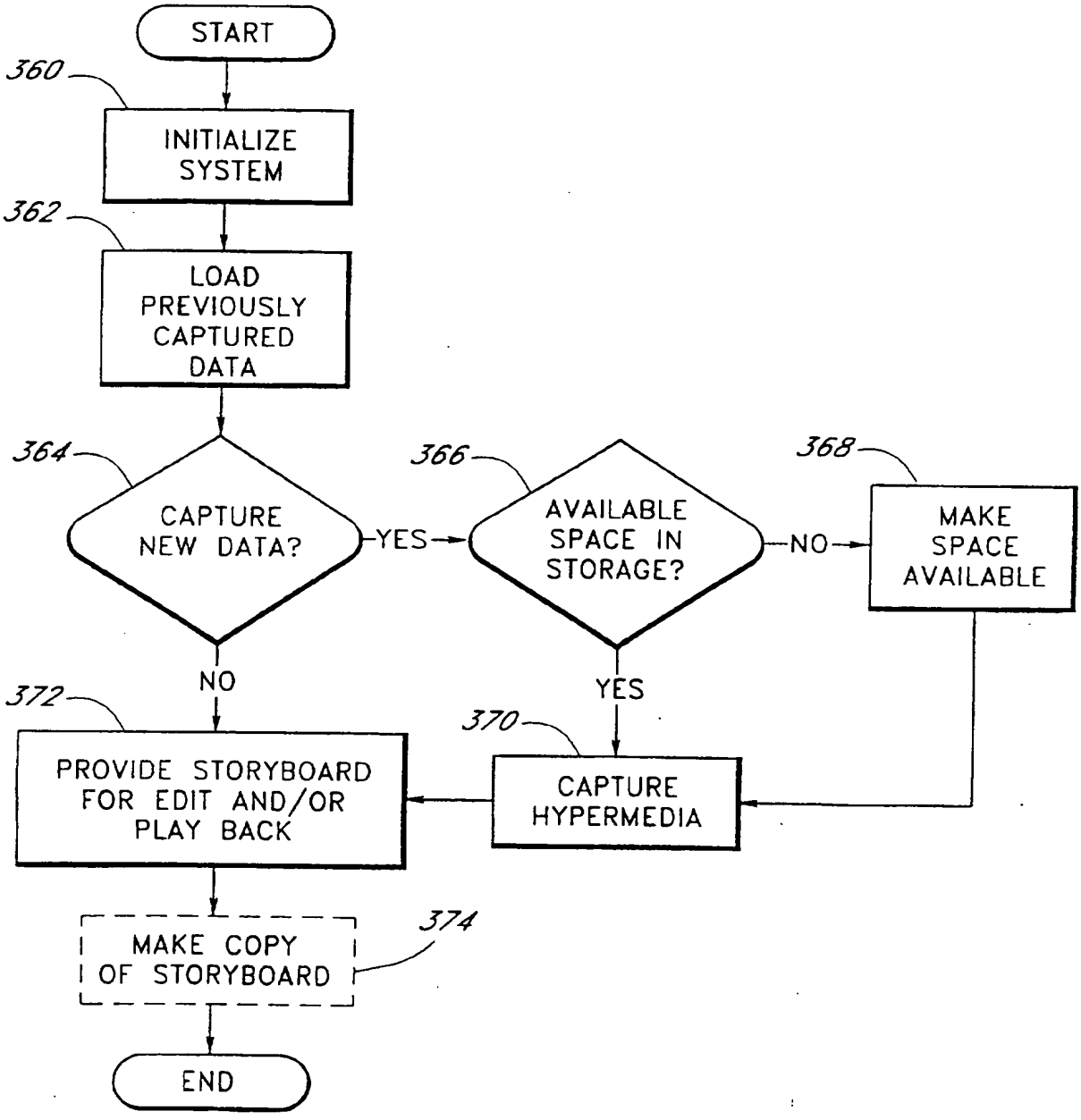

START
360
INITIALIZE SYSTEM
362
LOAD PREVIOUSLY CAPTURED DATA
364
CAPTURE NEW DATA?
YES
366
AVAILABLE SPACE IN STORAGE?
NO
368
MAKE SPACE AVAILABLE
NO
YES
372
PROVIDE STORYBOARD FOR EDIT AND/OR PLAY BACK
370
CAPTURE HYPERMEDIA
374
MAKE COPY OF STORYBOARD
END

Fig. 7

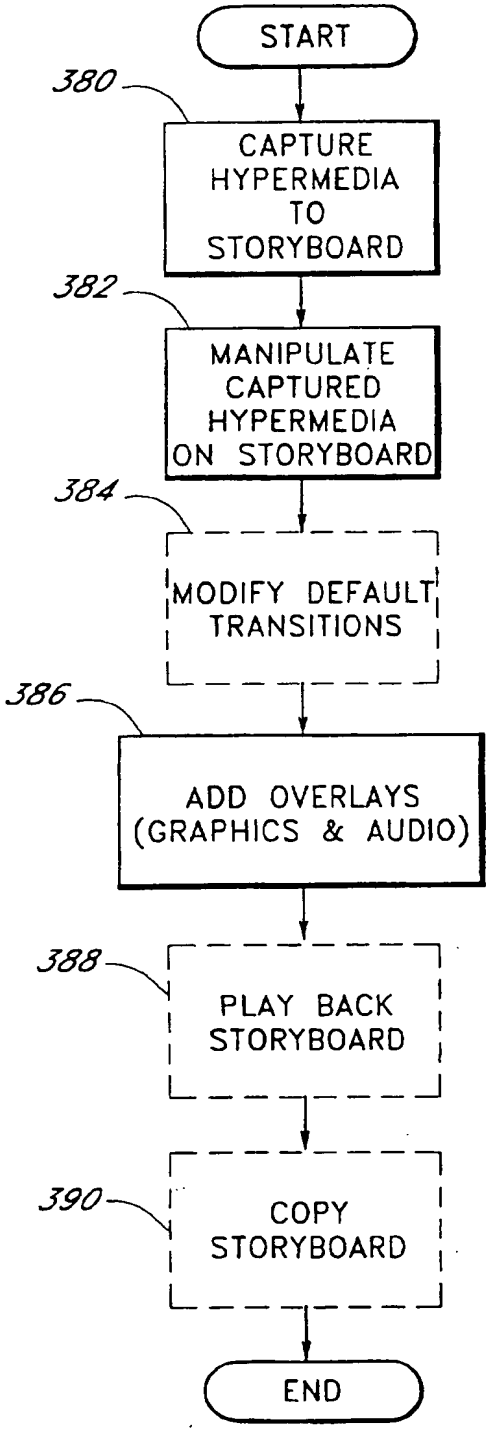

START
380
CAPTURE HYPERMEDIA TO STORYBOARD
382
MANIPULATE CAPTURED HYPERMEDIA ON STORYBOARD
384
MODIFY DEFAULT TRANSITIONS
386
ADD OVERLAYS (GRAPHICS & AUDIO)
388
PLAY BACK STORYBOARD
390
COPY STORYBOARD
END

Fig. 8

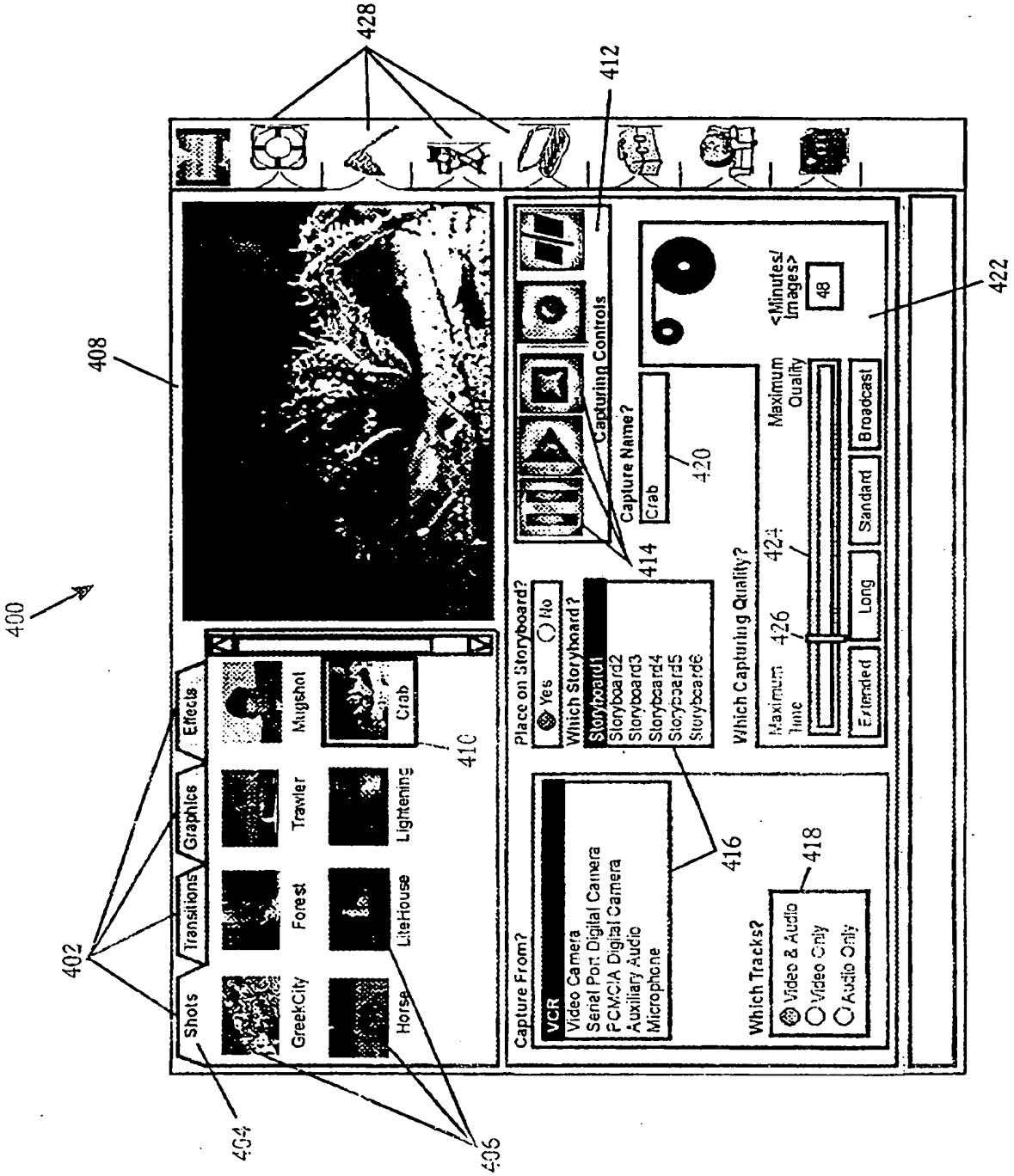

400
402
404
406
408
410
412
414
416
418
420
422
424
426
428
Shots
Transitions
Graphics
Effects
GreekCity
Forest
Trawler
Mugshot
Horse
LiteHouse
Lightening
Crab
Capturing Controls
Capture Name?
Crab
Place on Storyboard?
Yes
No
Which Storyboard?
Storyboard1
Storyboard2
Storyboard3
Storyboard4
Storyboard5
Storyboard6
Capture From?
VCR
Video Camera
Serial Port Digital Camera
PCMCIA Digital Camera
Auxiliary Audio
Microphone
Which Tracks?
Video & Audio
Video Only
Audio Only
Which Capturing Quality?
Maximum Time
Maximum Quality
<Minutes/Images>
48
Extended
Long
Standard
Broadcast

FIG. 9

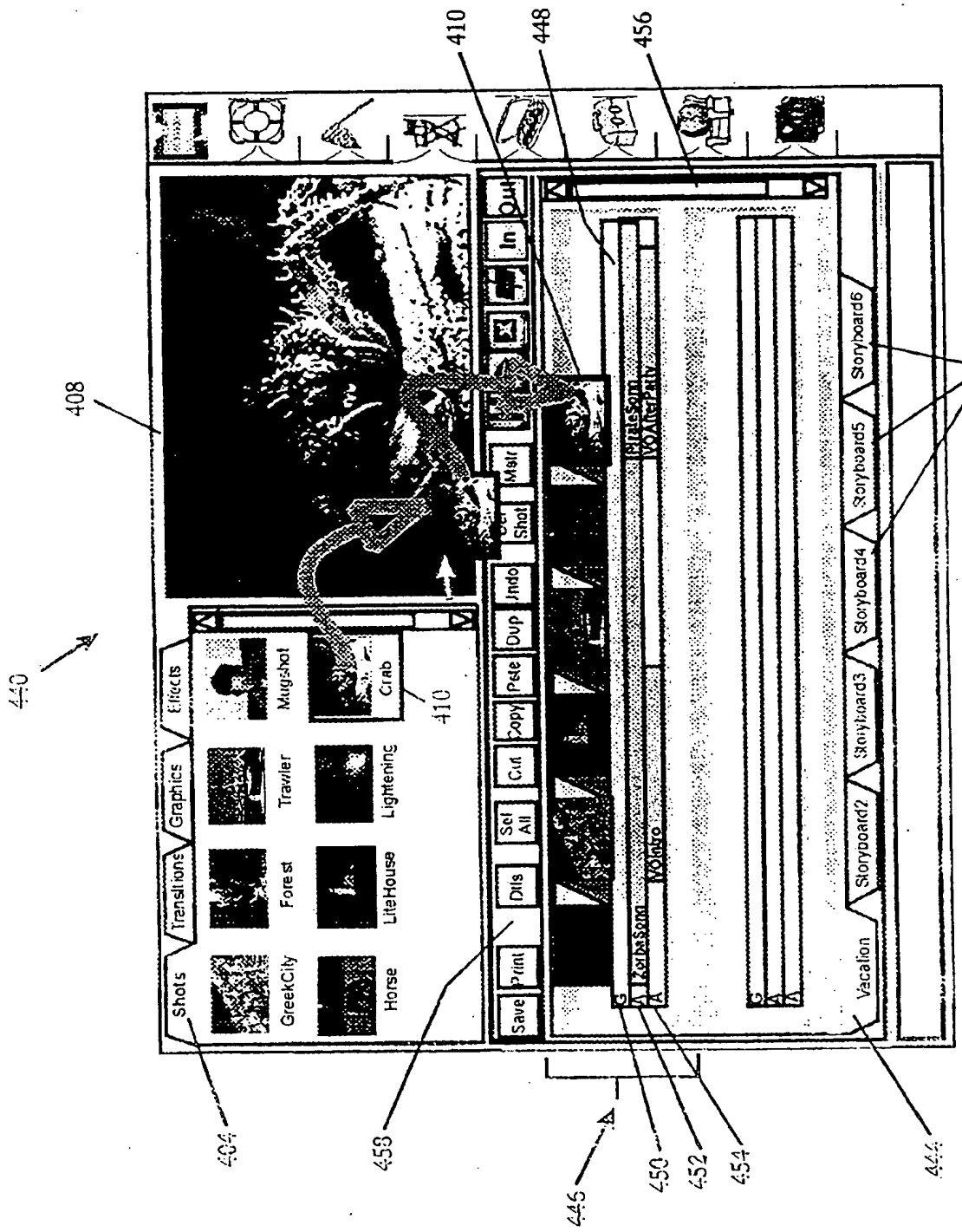

410
448
456
408
440
442
Shots
Transitions
Graphics
Effects
Save
Print
Dlts
Sel All
Cut
Copy
Pste
Dup
Undo
Shot
Mstr
In
Out
Crab
Mugshot
Lightening
Traviler
LiteHouse
Forest
Horse
GreekCity
Storyboard6
Storyboard5
Storyboard4
Storyboard3
Storyboard2
Vacation
404
458
446
450
452
454
444

FIG. 10

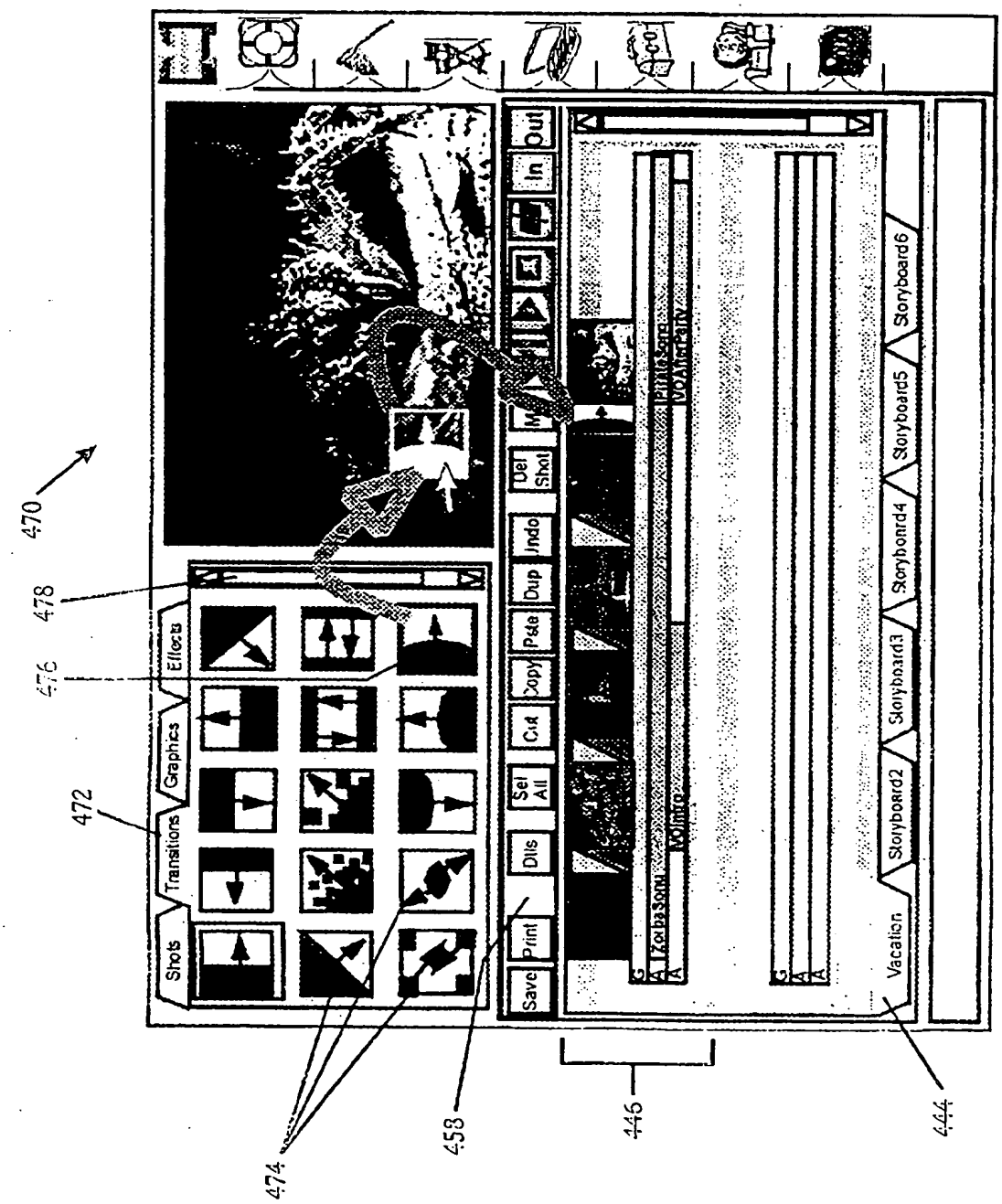

470
478
476
472
474
458
446
444
Shots
Transitions
Graphics
Effects
Save
Print
Dlls
Sel All
Cut
Copy
Pste
Dup
Undo
Del Shot
In
Out
Storyboard2
Storyboard3
Storybnrd4
Storyboard5
Storyboard6
Vacation

FIG. 11

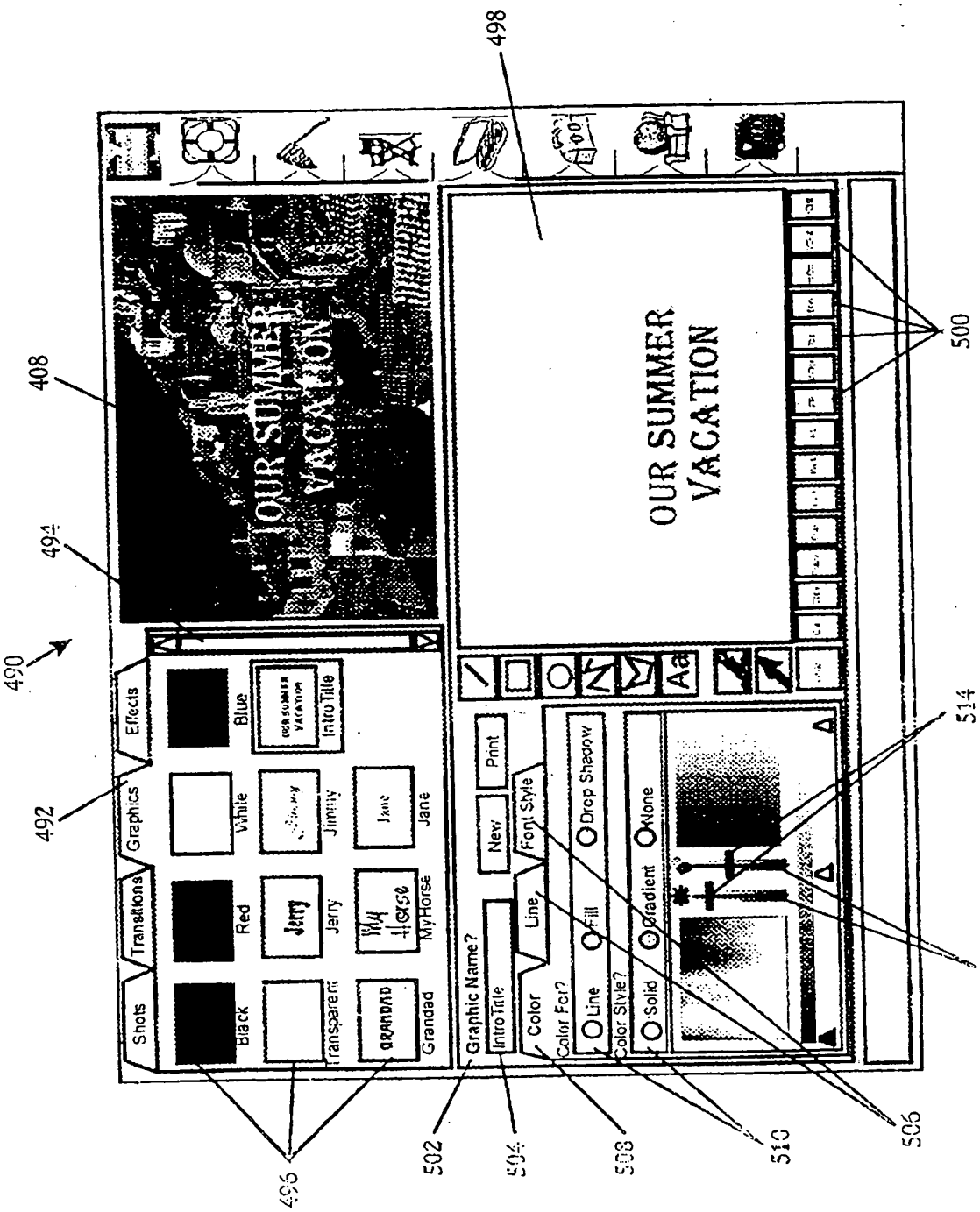

498
408
494
490
492
500
514
512
506
510
508
504
502
496
OUR SUMMER VACATION
Shots
Transitions
Graphics
Effects
Black
Red
White
Blue
Transparent
Jerry
Jimmy
Jane
Grandad
MyHorse
Intro Title
Graphic Name?
Color For?
Color Style?
Color
Line
Fill
Font Style
New
Print
Drop Shadow
Solid
Gradient
None
Aa

FIG. 12

INTERNATIONAL SEARCH REPORT

Interr ~nal Application No
PCT/US 97/13055

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G11B27/031 G11B27/34 H04N5/262 G06F3/033 G06F9/44
G06F17/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G11B H04N G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	EP 0 560 624 A (QUANTEL LTD) 15 September 1993 see column 5, line 42 - column 15, line 30 --- -/--	1,7-9, 21,25,32 33-38, 46, 48-50, 55-60

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 December 1997	23/12/1997

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Daalmans, F

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 97/13055

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Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A		2,3,7, 16-20, 25-27, 30,31, 39,50, 55,56
Y		44

X	EP 0 662 688 A (QUANTEL LTD) 12 July 1995 see column 4, line 30 - column 10, line 19	1,7-9, 25, 32-34, 36,38, 45,46
A		50,53, 55,56,58

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INTERNATIONAL SEARCH REPORT

Inter onal Application No
PCT/US 97/13055

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 273 220 A (QUANTEL LTD) 8 June 1994 see page 29, line 21 - page 33, line 15; figure 4	1,7,8, 21,25, 31-34, 38,46
A	see the whole document	50,55-58
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P,A		33, 35-38, 46, 48-50, 55,56, 59,60
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A	VOIGT-MULLER G: "SYSTEMVERGLEICH: cOMPUTER ODER KONVENTIONELLER SCHNITT?" RADIO FERNSEHEN ELEKTRONIK; ISSN 0033-7900, vol. 44, no. 3, 1995, BERLIN, DE, pages 52-53, XP002049217 page 53, right-hand column, line 10-21	1-6,33, 50,55
A	"SCHNELLER ZUGRIFF: VIDEO MACHINE VON FAST" RADIO FERNSEHEN ELEKTRONIK; ISSN 0033-7900, vol. 44, no. 11, 1 November 1995, BERLIN,DE, page 24, 26/27 XP000547885 see the whole document	1-5,8,9, 21,33, 35-38, 46,50-60
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INTERNATIONAL SEARCH REPORT

Inter onal Application No
PCT/US 97/13055

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Inter onal Application No
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formation on patent family members

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PCT/US 97/13055

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